SCIENTIFIC PROJECTS DEPARTMENT

Mars Express

MELACOM User Requirements Specification

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1 INTRODUCTION

The Mars Express spacecraft, developed by the European Space Agency (ESA), will be equipped with a UHF proximity communications package, named the Mars Express Lander Communications subsystem (MELACOM), developed by Defense Evaluation and Research Agency (DERA) under direct contract from ESA. The subsystem is procured by ESA and delivered to the Mars Express Prime Contractor ASTRIUM-SAS as a Principle Investigator (P.I.) provided instrument. This system will be available for proximity communications at Mars in the timeframe beginning in 2004 and stretching as late as 2008.

1.1 Purpose of the document

The document has been created to define the user requirements which are placed on MELACOM by the various parties engaged in Mars Exploration who will use the Mars Express Spacecraft as a communication relay between their Mars stations and Earth. The accommodation of the MELACOM on the Mars Express spacecraft and it's functional and physical interfaces to the spacecraft are controlled by the Mars Express Prime Contractor as for a P.I. provided instrument and are not addressed in this user requirements document.

1.2 Structure of the document

Chapter 2 provides a system overview of the Mars Express mission and the utilization of MELACOM over the mission lifetime to provide the required services to its users. Common user requirements are provided in Chapter 3 with specific user requirements given in subsequent chapters. Chapter 4 is dedicated to Beagle 2 requirements. Chapter 5 is dedicated to the Netlanders and Chapter 6 to Mars Sample Return (MSR) Canister requirements. Chapter 7 covers the verification of all user requirements.

Relevant technical details concerning each user is defined to the extent necessary to define the types of service required but no attempt is made to cover scheduling of access as this will be the subject of detailed mission planning which is performed elsewhere.

It should be noted that some of the technical data provided in the user specific chapters such as provisional link budgets, lander visibility periods and theoretical data volumes which can be achieved, are based on current best estimates and are provided to improve the system level understanding of service required. When MELACOM and users performance data become available these parameter tables will be superseded by an Interface Control Document (ICD) between MELACOM and each of its users. The ICD's will be controlled by the ESA project Office and signed off by the parties concerned.

1.3 Applicable Documents

AD1 CCSDS Proximity-1.0 Space Link Protocol, CCSDS 211.0. R-2 Red Book, Jan. 20. Annex 1.

AD2 Space-Ground ICD ME-ES-IF-5001 Issue 2.0

1.4 Reference Documents

RD1 Mars Express Mission Analysis – MAS Working Paper No.421 (ESOC).

RDZ Mars Express Consolidated Report on Mission Analysis – MEX-ESC-RP-5500.

2 MARS EXPRESS INTERFACES WITH MARS STATIONS

2.1 Mars Express General Information

In addition to this scientific mission as a Mars Orbiting spacecraft, Mars Express acts as a Service Access Point (SAP) to many stations in proximity around Mars via the CCSDS defined Space Data Link Proximity-1 Services. In the context of this document a station represents any UHF transceiver utilising the appropriate Proximity-1 protocols (CCSDS ref) and could include landers, rovers, sample return canisters, orbiting spacecraft, etc.

2.2 Mars Express Data

2.2.1 MARS ORBIT

The Mars Express spacecraft selected orbit parameters are as defined in MEX-ESC-RP-5500 (RD.2) Chapter 7.

2.2.2 MISSION PERIOD

Mars Express is launched in the period June 1-11 2003 with Mars Orbit Insertion planned nominally for December 25, 2003. After a period of orbit lowering maneuvers the spacecraft will begin nominal operations in late January or early February 2004. The nominal mission is planned to last to November 2005 with priority during this period to delivery and proximity services to the Beagle 2 Lander and in-orbit science operations. Following the nominal mission an extended mission is planned until November 2008 where more emphasis will be placed on Proximity Communication services with a continued program on in-orbit science measurements.

2.2.3 TECHNICAL INTERFACES

All users of the Mars Express proximity relay link facility will comply with the recommendations of the CCSDS Proximity-1 Space Link Protocol CCSDS 211.0-R-2 (AD.1) as modified or limited by this document.

Additional technical interface parameters not covered by AD.1 are addressed in the relevant chapters.

2.2.4 TRANSFER PROTOCOLS

Data from the Mars Express spacecraft to MELACOM will be provided via redundant RTU interfaces to redundant receivers on MELACOM. This interface carries the telecommands which will be in the ESA packet telecommand standard according to the Mars Express Space-Ground ICD ME-ESC-IF-5001 (AD.2). The MELACOM shall receive and validate it's own commands and transfer to the transmitter section those commands which are directed to the landers.

Lander commands (on the forward link) shall be wrapped in a CCSDS Proximity-1 Link transfer frame protocol according to CCSDS 211.0 (AD.1) incorporating a transfer frame header. The composite shall be transmitted at the predefined data rate with the required landers identification.

Lander telemetry (on the return link) shall be received by MELACOM wrapped in a CCSDS Proximity-1 link transfer frame protocol including convolutional encoding, if selected, according to CCSDS 211-0 (AD.1). MELACOM shall validate the transfer frame then remove the Proximity-1 transfer frame header and CRC coding. The remaining lander generated data shall be packetised by MELACOM with a timestamp in compliance with the ESA packet telemetry standard according to the Mars Express Space-Ground ICD ME-ESC-IF-5001 (AD.2) and shall then be transferred to the Spacecraft Solid State Mass Memory Unit via the redundant IEEE data bus interface.

2.3 MELACOM Subsystem Overview

The MELACOM subsystem is the Data Relay payload of Mars Express. The primary mission of MELACOM is to provide the data services for the Beagle II lander but it will be compatible also with NETLANDER and the NASA MARS SAMPLE RETURN canister.

2.3.1 Operational Scenario

Figure 1 provides an overview of the operational scenario. The Earth link communication is out with the scope of this document. All telecommands destaired for the MELACOM unit on the lander are routed through the RTU. Telemetry from the MELACOM unit are returned via the RTU however telemetry from the lander is timestamped on reception and is routed over the IEEE 1355. In the mass memory unit.

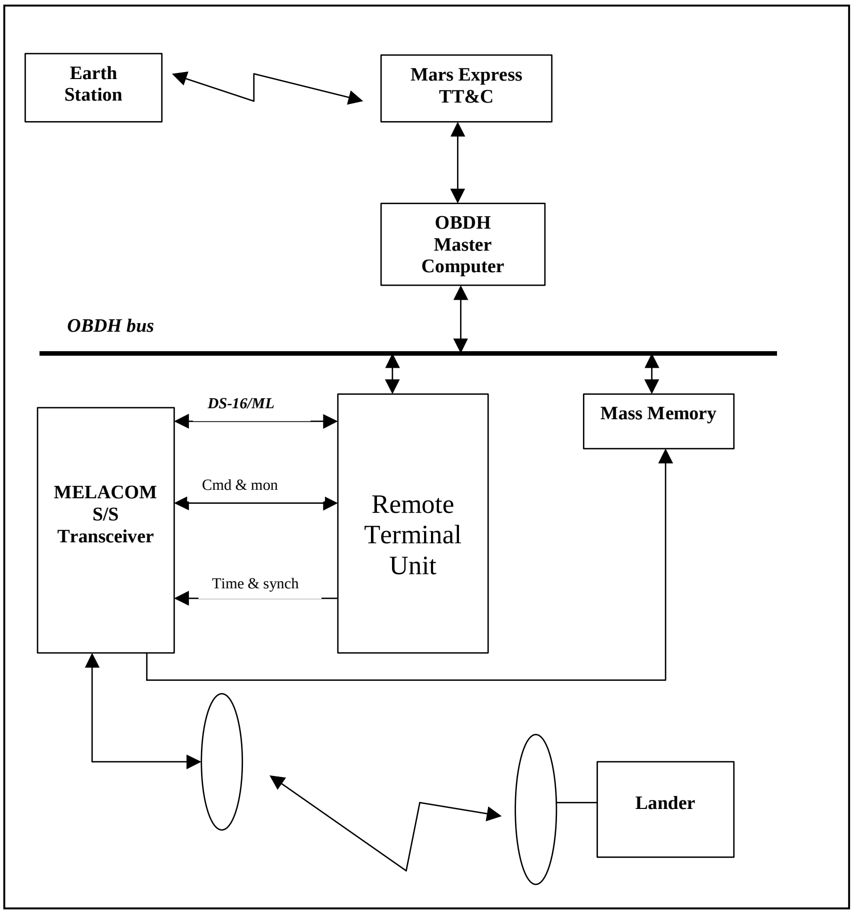


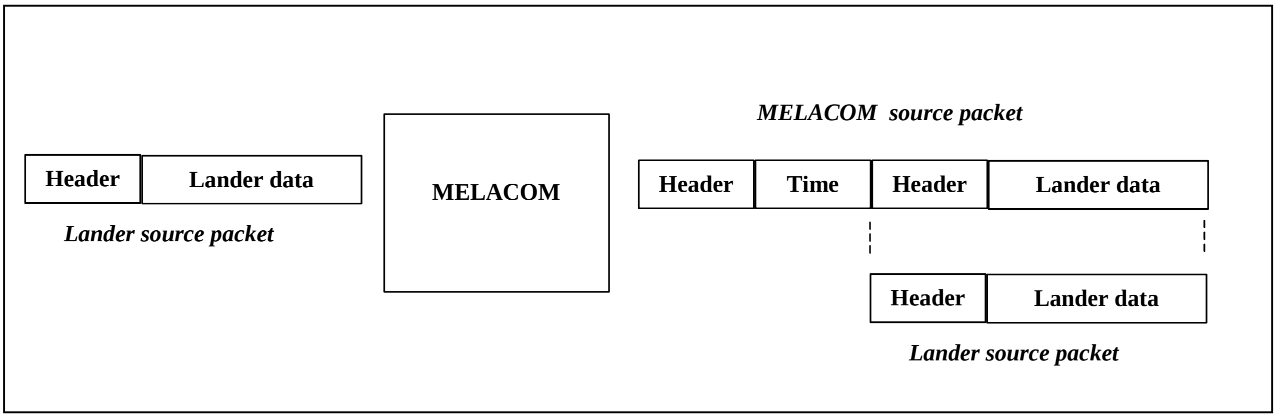
Figure 1 :

Overview of Operational Scenario

2.3.2 LANDER TELEMETRY FORMAT

Fig. 2 indicates time lander telemetry data flow through the MELACOM unit after removal of proximity link transfer frame heater and boiler.

Figure 2 : Lander telemetry data flow



2.3.3 TIMELINE

Spacecraft timeline execution procedure sends:

- TC addressed to the OBDH RTU for MELACOM subsystem switch on and initialization
- TC addressed to MELACOM subsystem for configuration
- TC addressed to the lander via MELACOM

T1: The time tag of the TC addressed to the OBDH RTU occurs, and the TC are executed;

- ✓ The OBDH switches on the MELACOM subsystem
- ✓ The MELACOM subsystem performs the default initialization and self check

T1 + 8s: The OBDH starts to poll the MELACOM subsystem for housekeeping TM acquisition

T1 + 16s : The MELACOM subsystem executes the synchronisation of its Local Time with the spacecraft usin the synchronisation signals delivered by the OBDH.

T2 : The time tag of the TC addressed to MELACOM subsystem occurs and the OBDH RTU sends the configuration TCs to MELACOM. These TCs specify :

- ✓ the begin/and time of each communication
- ✓ for each communication session: protocol configuration / TM data rate / …etc.

T3 : MELACOM subsystem performs the acquisition sequence with the lander.

T4 : On successful completion of the acquisition sequence a communication session is initiated between MELACOM and the lander in which commands are transmitted to the lander on the forward link and lander telemetry data is returned to MELACOM where it is time stamped and packetised according to RD1 for routing to the Mass Memory Unit.

T5 : The MELACOM subsystem will terminate the communications session when the predefined end time occurs.

Note: At any time during a communication's session, a loss of link will cause a return to T3.

T6 : On completion of the acquisition of all MELACOM telemetry by the OBDH the subsystem is switched-off.

3 NON USER-SPECIFIC REQUIREMENTS

3.1 CCSDS Applicability

3.1.1 APPLICABILITY OF CCSDS 211.0-R-2 TO MELACOM USER INTERFACES

The Proximity-1 Space Link Protocol CCSDS 211.0-R-2 dated Jan. 2000 is fully applicable to the MELACOM User Requirements Specification except:

- where otherwise stated in the following table;
- where options are given in the standards document the selected option is specified and
- where TBD's exist these are identified and where possible quantified for the Mars Express application.

3.1.2 PROXIMITY STANDARD APPLICABILITY

No.	***Para. No.***	***Applicability***	***Comments***
1	3.2.1.1.2.	N/A	
2	3.2.1.1.3.	N/A	
3	3.2.1.2.	N/A	
4	3.2.1.3.	N/A	
5	3.2.1.4..	N/A	
6	3.2.4.1.		Acquisition sequence shall consist of a one-zero data pattern
7	3.2.4.2.		The idle sequence shall consist of a one-zero data pattern
8	3.2.5.		Selected Data Rates Forward link 2000 and 8000 bps Return Link 2/4/8/16/32/64 and 128000 hps.
9	3.3.2 and 3.3.4		Carrier Frequency Stability Long term <1 x 10^{-8} Allan variance < 5 x 10^{-12} per second Phase noise 10Hz < -120dBc/Hz 100Hz < -140 dBc/Hz 1kHz < -145 dBC/Hz 10KHz < -150 dBc/Hz 50KHz < -150dBc/Hz
10	3.3.6.2.	N/A	
11	3.3.6.3.	N/A	
12	3.3.6.4.	N/A	
13	4.1.4.3.	N/A	
14	4.1.6.3		Transfer Frame Data Field: see also the Mars Express Space to Ground ICD ME-ESC-IF-5001 (AD.2) for source packet parameter definition.
15	4.2.2.7.		No frequency change capability is required
16	4.2.2.8.		No rate change capability is required during any given communications sessions
17	4.2.7.1.2.	N/A	
18	4.2..7.2.	N/A	
19	B.2.2.2.4.		Bits 8 and 9 00 not used (reserved) 01 Convolutional G2 non inverted 10 uncoded 11 Convolutional G2 inverted
20	B.2.2.3.4.		Bits 8 and 9 00 not used (reserved) 01 Convolutional G2 non inverted 10 uncoded 11 Convolutional G2 inverted
21	C.3.2.		Bits 8 and 9 00 not used (reserved) 01 Convolutional G2 non inverted 10 uncoded 11 Convolutional G2 inverted
22	C.5.1.4.		Bits 8 and 9 00 not used (reserved) 01 Convolutional G2 non inverted 10 uncoded 11 Convolutional G2 inverted
23	C.5.2.4.		Bits 8 and 9 00 not used (reserved) 01 Convolutional G2 non inverted 10 uncoded 11 Convolutional G2 inverted

3.2 Additional MELACOM User Interface Requirements

MELACOM Output Power = 5 Watts RF min. (7 dBW).

MELACOM Antenna Performance (installed on spacecraft)

Boresight Gain	=	12 dB min.
Gain at ± 50º from boresight	=	2 dB min
Cross-polarisation	≤	-15 dB
EIRP at boresight	=	19 dBm min
MELACOM Receiver Carrier Threshold	=	-130 dBm at 300° K
Receiver Tracking Capability	=	± 5 KHZ in addition to the doppler Tracking requirement in para. 3.3.6.1. Of CCSDS standard.

MELACOM time shall be synchronized to spacecraft time by means of the spacecraft time synchronization service.

MELACOM time synchronization accuracy	=	1 иs
MELACOM time stamp resolution	=	1 иs

4 BEAGLE 2 LANDER USER REQUIREMENTS

Beagle 2 is a small (25 kg station; 60 kg entry mass) biological and physical surface station provided to the Mars Express project by an UK consortium lead by the Open University and the University of Leicester.

4.1 Mission Period

Beagle 2 will be delivered to Mars onboard the Mars Express spacecraft and will land on the surface Dec. 25, 2003 (TBC). The nominal lifetime of the lander is 180 Sols but provision for an extended mission is included to a maximum of 1 Martian year.

During the primary mission of 180 Sols, Beagle 2 communications shall be a high priority operation for Mars Express. During the extended mission communications shall be provided by Mars Express on a best effort basis within the constraints of orbiter science and other Martian station communications.

4.2 Technical Interface Requirements

The interface requirements with the Mars Express spacecraft are expressed in terms of the physical layer, the protocol, and data volume. As data volume is a function of link performance, range and duration of visibility periods the current best estimates of these parameters are included for information.

4.2.1 Physical Layer and Protocol

The Beagle 2 physical layer and protocol requirements are compliant with the general MELACOM user requirements given in Paragraphs 2.2.2, 2.2.3 and 3.1. of this document.

4.2.2 Additional Beagle Specific Interface parameters

Beagle Output Power – 5 Watts RF min (7 dBW)

Maximum continuous transmitter Operating Time	=	20 minutes
Beagle Antenna Performance		
Boresight gain	=	4 dB min
Gain at ± 50º from boresight	=	1 dB min
EIRP at boresight	=	10.5 dBW
Beagle Receiver Carrier Threshold	=	-128 dBm

4.2.3 Data Volume

Beagle requires an average return link capacity (Beagle to MELACOM) of 10 M bits per day.

4.2.4 UMBILICAL INTERFACE

During the cruise phase MELACOM shall support all communications with the Beagle via an umbilical connection. Interface parameters of this will be detailed in the MELACOM to Beagle ICD.

4.3 MELACOM – BEAGLE link budgets

Link budgets have been prepared by A.J. WINTON ESTEC/TOS

Forward and return links are based on currently available performance estimates of Beagle and MELACOM. These budgets will be updated later as design data becomes available and form the basis for a MELACOM to BEAGLE ICD.

Forward Link: MELACOM to Beagle 2 (2 kbps)

Forward Link		Beagle (b-sight)	Beagle (50deg)
Orbit			
Periapsis	km	280	280
Apoapsis	km	11500	11500
Location			
Max Doppler Offset	Hz		
Max Doppler Rate	Hz/s		
Transmit (Orbiter)			
RF Power	dBW	7.00	7.00
Transmit Antenna Gain	dBi	12.00	2.00
Losses	dB	0.00	0.00
EIRP	dB	19.00	9.00
Space Link			
Forward Link Frequency	MHz	437.10	437.10
Link Distance	Km	22710	5084
Space Losses	dB	172.38	159.38
Receive (Lander)			
Receive Antenna gain	dBi	4.00	1.00
Losses	dB	1.50	1.50
Noise Figure	dB	3.00	3.00
System Noise Temperature	K	654.50	654.50
Receive G/T	dB/K	-25.66	-28.66
Received Signal Power: S	dBm	-120.88	-120.88
Received S/No	dBHz	49.56	49.56
Lander Receiver Performance			
Carrier Loop Bandwidth	Hz	1000	1000
Carrier Loop SNR	dB		
Threshold (carrier)	dBm	-129.48	-129.48
Threshold (data)	dBm	-125.03	-125.03
Actual threshold (carrier)	dBm	-128.00	-128.00
Pull In Range	Hz		
Tracking Range	Hz		
Max Time To Lock	s		
Carrier Phase Noise	deg		
Receive Power Margin	dB	3.15	3.15
Carrier Margin	dB	3.00	3.00
Forward Data Rate			
Modulation & Other Loss	dB	1.84	1.84
Bit Rate	bps	2000	2000
Required Eb/No	dB	9.60	9.60
Data Margin (3dB)	dB	5.12	5.12
Doppler			
Doppler Measurement Epoch	sec		
Velocity Standard Deviation	mm/sec		

(*)Power margin is worst case of data or carrier

Author: A J Winton (TOS-ETT)

Forward Link: MELACOM to Beagle 2 (8 kbps)

Forward Link		Beagle (b-sight)	Beagle (50deg)
Orbit			
Periapsis	km	280	280
Apoapsis	km	11500	11500
Location			
Max Doppler Offset	Hz		
Max Doppler Rate	Hz/s		
Transmit (Orbiter)			
RF Power	dBW	7.00	7.00
Transmit Antenna Gain	dBi	12.00	2.00
Losses	dB	0.00	0.00
EIRP	dB	19.00	9.00
Space Link			
Forward Link Frequency	MHz	437.10	437.10
Link Distance	Km	11556	2587
Space Losses	dB	166.51	153.51
Receive (Lander)			
Receive Antenna gain	dBi	4.00	1.00
Losses	dB	1.50	1.50
Noise Figure	dB	3.00	3.00
System Noise Temperature	K	654.50	654.50
Receive G/T	dB/K	-25.66	-28.66
Received Signal Power: S	dBm	-115.01	-115.01
Received S/No	dBHz	55.43	55.43
Lander Receiver Performance			
Carrier Loop Bandwidth	Hz	1000	1000
Carrier Loop SNR	dB		
Threshold (carrier)	dBm	-129.48	-129.48
Threshold (data)	dBm	-119.01	-119.01
Actual threshold (carrier)	dBm	-128.00	-128.00
Pull In Range	Hz		
Tracking Range	Hz		
Max Time To Lock	s		
Carrier Phase Noise	deg		
Receive Power Margin	dB	3.00	3.00
Carrier Margin	dB	8.87	8.87
Forward Data Rate			
Modulation & Other Loss	dB	1.84	1.84
Bit Rate	bps	8000	8000
Required Eb/No	dB	9.60	9.60
Data Margin (3dB)	dB	4.96	4.96
Doppler			
Doppler Measurement Epoch	sec		
Velocity Standard Deviation	mm/sec		

(*)Power margin is worst case of data or carrier

Author: A J Winton (TOS-ETT)

Return Link: Beagle 2 to MELACOM

Return Link		Beagle (b-sight)	Beagle (50deg)
Orbit			
Periapsis	km	280	280
Apoapsis	km	11500	11500
Location			
Max Doppler Offset	Hz		
Max Doppler Rate	Hz/s		
Transmit (Lander)			
RF Power	dBW	7.00	7.00
Transmit Antenna Gain	dBi	4.00	1.00
Losses	dB	0.50	0.50
EIRP	dB	10.50	7.50
Space Link			
Return Link Frequency	MHz	401.59	401.59
Link Distance	Km	25390	5684
Space Losses	dB	172.61	159.61
Receive (Orbiter)			
Receive Antenna gain	dBi	12.00	2.00
Losses	dB	1.00	1.00
Noise Figure	dB	3.00	3.00
System Noise Temperature	K	466.53	466.53
Receive G/T	dB/K	-15.69	-25.69
Received Signal Power: S	dBm	-121.11	-121.11
Received S/No	dBHz	50.80	50.80
Orbiter Receiver Performance			
Carrier Loop Bandwidth	Hz	1000	1000
Carrier Loop SNR	dB		
Threshold (carrier)	dBm	-130.48	-130.48
Threshold (data)	dBm	-125.11	-125.11
Actual threshold (carrier)	dBm	-130.00	-130.00
Pull In Range	Hz		
Tracking Range	Hz		
Max Time To Lock	s		
Carrier Phase Noise	deg		
Receive Power Margin (*)	dB	3.00	3.00
Carrier Margin	dB	4.24	4.24
Return Data Rate			
Modulation & Other Loss	dB	1.84	1.84
Bit Rate	bps	8000	8000
Required Eb/No	dB	4.50	4.50
Data Margin (3dB)	dB	5.43	5.44
Doppler			
Doppler Measurement Epoch	sec		
Velocity Standard Deviation	mm/sec		

(*)Power margin is worst case of data or carrier

Author: A J Winton (TOS-ETT)

4.4 Link Performance and Data Volume

The following analysis of Beagle – Mars Express visibility periods, viewing angles, link distances and subsequent overall forward and return link performances have been performed by ESOC (M. HECHLER and A. Yanez) based on the link budgets given in chapter 4.3. and are extracted from the Mars Express Mission Analysis paper RD1 (See Annex 2). The analysis is based on best currently available data and the predicted data volumes assume that all feasible communication windows are utilized without considering the possible constraints of other payloads.

As for the link budgets this analysis will be updated as design data becomes available and will also become part of the MELACOM to BEAGLE ICD.

5 NELTLANDER USER REQUIREMENTS

NETLANDER consists of a group of four small (19 kg station; 52 kg entry mass) atmospheric, seismic and geological surface stations provided by a consortium let by CNES (Centre National d'Etudes Spatiales).

5.1 Mission Period

NETLANDER stations will be delivered to Mars as part of the NASA/CNES cooperation on the Mars Sample Return programme. The expected launch is the end 2005 with arrival at Mars expected in August 2006. The nominal lifetime of the lander is a minimum of 1 Martian year.

Mars Express is in its 2nd Martian year of operations when NETLANDER communications are required and, as this is the extended mission portion of the Mars Express, will be a prime objective for Mars Express.

5.2 Technical Interface Requirements

The interface requirements with the Mars Express spacecraft are expressed in terms of the physical layer, the protocol and the data volume.

Data volume available on the return link from Netlander stations to Mars Express is a function of link performance range and duration of visibility periods. Whereas a current best estimate of link performance is given in para.5.3. of this document, visibility periods and link distances have not yet been analysed. This work will be persued as performance figures mature and Netlander station landing site information becomes available.

5.2.1 Physical Layer and Protocol

The Netlander physical layer and protocol requirements are compliant with the general MELACOM user requirements given in paragraphs 2.2.2., 2.2.3 and 3.1. of this document.

5.2.2 Additional Netlander Specific Interface Parameters

Netlander Output Power	=	5 Watts RF min (7dBW)
Maximum Continuous Transmitter Operating Time	=	TBD minutes
Netlander Antenna Performance		
Boresight Gain	=	3 dB min
Gain at ± 50º from Boresight	=	-3dB min
EIRP at boresight	=	6.5 dBW
Netlander Receiver Carrier threshold	=	-130 dBm max

5.2.3 DATA VOLUME

The average return link capacity assigned to the Netlanders is 10 M bits per day.

Netlander have requested a data volume of 100 M bits/week per Netlander (4 Netlanders). This will be assessed based on the available share of overall Mars Express downlink capability.

5.3 Netlanders – MELACOM link budgets

Link budgets have been prepared by A.J. Winton ESTEC/TOS for forward and return links based on currently available performance estimates of Netlanders and MELACOM. These budgets will be updated as design data becomes available and form the basis for a Netlander to MELACOM ICD.

Forward Link: MELACOM to Netlander (2 kbps)

Forward Link		Netlander (b-sight)	Netlander (50deg)
Orbit			
Periapsis	km	280	280
Apoapsis	km	11500	11500
Location			
Max Doppler Offset	Hz		
Max Doppler Rate	Hz/s		
Transmit (Orbiter)			
RF Power	dBW	7.00	7.00
Transmit Antenna Gain	dBi	12.00	2.00
Losses	dB	0.00	0.00
EIRP	dB	19.00	9.00
Space Link			
Forward Link Frequency	MHz	437.10	437.10
Link Distance	Km	20241	3208
Space Losses	dB	171.38	155.38
Receive (Lander)			
Receive Antenna gain	dBi	3.00	-3.00
Losses	dB	1.50	1.50
Noise Figure	dB	3.00	3.00
System Noise Temperature	K	654.50	654.50
Receive G/T	dB/K	-26.66	-32.66
Received Signal Power: S	dBm	-120.88	-120.88
Received S/No	dBHz	49.56	49.56
Lander Receiver Performance			
Carrier Loop Bandwidth	Hz	1000	1000
Carrier Loop SNR	dB		
Threshold (carrier)	dBm	-129.48	-129.48
Threshold (data)	dBm	-125.03	-125.03
Actual threshold (carrier)	dBm	-130.00	-130.00
Pull In Range	Hz		
Tracking Range	Hz		
Max Time To Lock	s		
Carrier Phase Noise	deg		
Receive Power Margin	dB	3.15	3.15
Carrier Margin	dB	3.00	3.00
Forward Data Rate			
Modulation & Other Loss	dB	1.84	1.84
Bit Rate	bps	2000	2000
Required Eb/No	dB	9.60	9.60
Data Margin (3dB)	dB	5.12	5.12
Doppler			
Doppler Measurement Epoch	sec		
Velocity Standard Deviation	mm/sec		

(*)Power margin is worst case of data or carrier

Author: A J Winton (TOS-ETT)

Forward Link: MELACOM to Netlander (8 kbps)

Forward Link		Netlander (b-sight)	Netlander (50deg)
Orbit			
Periapsis	km	280	280
Apoapsis	km	11500	11500
Location			
Max Doppler Offset	Hz		
Max Doppler Rate	Hz/s		
Transmit (Orbiter)			
RF Power	dBW	7.00	7.00
Transmit Antenna Gain	dBi	12.00	2.00
Losses	dB	0.00	0.00
EIRP	dB	19.00	9.00
Space Link			
Forward Link Frequency	MHz	437.10	437.10
Link Distance	Km	10300	1632
Space Losses	dB	165.51	149.51
Receive (Lander)			
Receive Antenna gain	dBi	3.00	-3.00
Losses	dB	1.50	1.50
Noise Figure	dB	3.00	3.00
System Noise Temperature	K	654.50	654.50
Receive G/T	dB/K	-26.66	-32.66
Received Signal Power: S	dBm	-115.01	-115.01
Received S/No	dBHz	55.43	55.43
Lander Receiver Performance			
Carrier Loop Bandwidth	Hz	1000	1000
Carrier Loop SNR	dB		
Threshold (carrier)	dBm	-129.48	-129.48
Threshold (data)	dBm	-119.01	-119.01
Actual threshold (carrier)	dBm	-130.00	-130.00
Pull In Range	Hz		
Tracking Range	Hz		
Max Time To Lock	s		
Carrier Phase Noise	deg		
Receive Power Margin	dB	3.00	3.00
Carrier Margin	dB	8.87	8.87
Forward Data Rate			
Modulation & Other Loss	dB	1.84	1.84
Bit Rate	bps	8000	8000
Required Eb/No	dB	9.60	9.60
Data Margin (3dB)	dB	4.96	4.96
Doppler			
Doppler Measurement Epoch	sec		
Velocity Standard Deviation	mm/sec		

(*)Power margin is worst case of data or carrier

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Return Link: Netlander to MELACOM

Return Link		Netlander (b-sight)	Netlander (50deg)
Orbit			
Periapsis	km	280	280
Apoapsis	km	11500	11500
Location			
Max Doppler Offset	Hz		
Max Doppler Rate	Hz/s		
Transmit (Lander)			
RF Power	dBW	7.00	7.00
Transmit Antenna Gain	dBi	3.00	-3.00
Losses	dB	0.50	0.50
EIRP	dB	9.50	3.50
Space Link			
Return Link Frequency	MHz	401.59	401.59
Link Distance	Km	22627	3586
Space Losses	dB	171.61	155.61
Receive (Orbiter)			
Receive Antenna gain	dBi	12.00	2.00
Losses	dB	1.00	1.00
Noise Figure	dB	3.00	3.00
System Noise Temperature	K	466.53	466.53
Receive G/T	dB/K	-15.69	-25.69
Received Signal Power: S	dBm	-121.11	-121.11
Received S/No	dBHz	50.80	50.80
Orbiter Receiver Performance			
Carrier Loop Bandwidth	Hz	1000	1000
Carrier Loop SNR	dB		
Threshold (carrier)	dBm	-130.48	-130.48
Threshold (data)	dBm	-125.11	-125.11
Actual threshold (carrier)	dBm	-130.00	-130.00
Pull In Range	Hz		
Tracking Range	Hz		
Max Time To Lock	s		
Carrier Phase Noise	deg		
Receive Power Margin (*)	dB	3.00	3.00
Carrier Margin	dB	4.24	4.24
Return Data Rate			
Modulation & Other Loss	dB	1.84	1.84
Bit Rate	bps	8000	8000
Required Eb/No	dB	4.50	4.50
Data Margin (3dB)	dB	5.44	5.44
Doppler			
Doppler Measurement Epoch	sec		
Velocity Standard Deviation	mm/sec		

(*)Power margin is worst case of data or carrier

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5.4 Link Performance and Data Volume

Analysis to be performed when link performance and selected landing site data matures.

5.5 Synchronisation

Netlanders require a synchronization between stations of better than 20 m sec. (TBC).

Mars Express via the MELACOM will provide a time synchronisation message to the Neltanders with a resolution of 1 m sec. once per week (tbc).

6 MARS SAMPLE RETURN CANISTER TRACKING REQUIREMENTS

The Mars Sample Return (MSR) mission will place samples of Mars in canisters which will be launched from the Mars surface into a 600 km altitude circular orbit. A rendez-vous with the orbiting canisters by a sample return spacecraft will take place once the canister is tracked and located in orbit. Tracking will be performed by satellites in orbit around Mars. The Mars Sample return mission is a joint NASA/CNES mission.

6.1 Mission Period

The first Mars Sample Return mission will be launched in 2003 with a subsequent mission planned for 2005. After a period of time on the surface of Mars for sample gathering a canister will be launched into Mars orbit sometime in 2004 for the first mission and 2006 for the second. Immediately upon launch from Mars operational satellites around Mars will attempt to track the canister using UHF signals received from the canister.

Mars Express will have started its primary mission when the first canister tracking will be required and a high priority will be place on tracking the canister with minimum interference with on-going operations. For the second canister Mars Express will be in its extended mission phase of operations and will be used to track the canister with a high priority.

6.2 Technical Interface Requirements

The canister is in principle a simple UHF transceiver with no data modulation. The canister will either be transmitting a carrier driven by an on-board oscillator or it will be transmitting a carrier that is coherently locked to a signal received from Mars Express, provided the signal is of sufficient strength. In either case, the processing at the MELACOM is the same and consists of receiving the canister signal, down converting it, digitising and then storing the Most Significant Bit (sign bit). These data are packetised and time stamped by MELACOM.

6.2.1 Physical Layer

The MSR transmissions are carrier only – no data is transmitted. The physical layer requirements are compliant with the general MELACOM user requirements given in paragraph 2.2.2. and 3.1. of this document.

6.2.2 Additional MSR Specific Interface Parameters

Power:

EIRP	=>	>14 dBm
Transmitter	=>	100 milliwatts RF
Max operation time	=>	Maximum visibility (TBD) mn. (Requires solar illumination)
Receive Threshold	=>	-110 dBm (lock on incoming signal from MELACOM)

6.2.3 DATA VOLUME

Sampling Rate => ~40ksps for 16 KHz baseband filter centered nominal Rx frequency

Sample Size => 1 bit/sample (MSB after digitisation)

Data Rate => 40 kbps

Maximum Tracking TIime=> 4 mn depending on Mars Express - MSR visibility periods and downlink capacity

6.2.4 CANISTER TRACKING OPERATION MODES

Two distinct MELACOM operating modes are required for canister tracking operations:

Listen Only:

The MELACOM receiver will generate data on the received RF spectrum for a commanded period of time.

Transmit and Listen:

The MELACOM will transmit a carrier signal and generate data on the received RF spectrum for a commanded period of time.

6.3 MSR Canister – MELACOM Link Budgets

Link budgets are to be prepared for the MSR Canister tracking modes.

6.4 Link Performance and Visibility Periods

Link performance and visibility analyses will be performed when the link budgets are settled and canister orbital data is known.

7 VERIFICATION

All requirements specified in the MELACOM USER REQUIREMENTS document shall be verified under the environmental conditions given in the PID'A.

ANNEX 1

PROXIMITY-1 SPACE LINK PROTOCOL

CCSDS 211.0-R-2

RED BOOK

Jan.2000

ANNEX 2

MARS EXPRESS

CONSOLIDATED MISSION ANALYSIS REPORT

- Lander Communications -